Subject Index

Aging and spatial vision 108
Amacrine cells
  corticotropin releasing factor 13
  dopaminergic 10
    tonic inhibition 12
  GABAergic 40
    turtle 3, 4
  glucagon in turtle 16, 17
  glycinergic in turtle 4, 5
  5-HT in turtle 7, 9
  met-enkephalin 17, 18
  neuropeptide Y 14, 16
  neurotensin 19, 21
  scotopic threshold response 143
  somatostatin 21
  tyrosine hydroxylase positive 10
Amino acids and dopamine release 12
cAMP
  Limulus eye effects 338
    octopamine 346–8
  retinal role 351
Animal models for retinitis pigmentosa 307–17
  cat
    progressive retinal atrophy 311, 312
    Rdy gene 311
  dog
    cone degeneration 315
    congenital stationary night blindness 314
    erd gene 313
    prcd gene 313, 314
    progressive retinal atrophy 314, 315
    rcd 1 gene 312, 313
    rcd 11 gene 313
  mouse
    rd gene 309, 310
    rds gene 310, 311
  rat
    rdy gene 315–17
Antibody
  polyclonal RALBP 190, 191
  RET-PE 2 50–2
Antigens, CNS cells and MHC 83
Apical–basal heterogeneity, interphotoreceptor matrix 216, 217
Aspartate
  light-adapted electroretinogram 154
  turtle retina 1, 2
Astrocytes in retinal development 59
ATPase in retinal pigment epithelium culture 279
ATPase staining, retinal pigment epithelium transplant 78

Behaviour, dark-rearing chimpanzees 107, 108
Bipolar cells
  glycine and GABA 40
  5-HT in turtle 6
    Landolt club 8
    visual streak 8
  light responses of dark adapted 37
  rod input–output 33
  synaptic connections 30

Calcium and cell division 258, 259
Cell culture, retinal pigment epithelium 53, 54, 251–85
  apical processes 272, 273
  biopsy 284
  calcium ion increase 266, 267
  choroidal cell co-culture 284
  choroidal contamination 268
  cryopreservation 268, 269
  dome 274, 279
  evaluation 269–83
  extracellular matrix 272, 273
    features 275
  floater production 266, 269
  harvesting 254–6
  intercellular junction complex 273
  intermediate filaments 277
  in vivo comparison 269, 270
  ion transport 274
  lysosomal enzymes 283
  media 257, 259–63
    bovine retina extract 261
    calcium 258, 259, 261, 262
      low 263–5
    components 260

in vivo retinal pigment epithelium 259
nucleotides 262
porous supports 283
retinoids 262–4
melanization 275
melanosomes 275, 276
microfilaments 278
mitosis 263–5
monolayer, electron microscopy 270, 271
morphology 270, 271
origin 253–5
proliferation 277
curve 267, 268
serum reduction 257, 258
serum retinol binding protein 280, 281
sheets 264
sodium pump 279
autoradiography 280
stress fibres 278
structural polarity 270, 272, 273
transplantation 284
vimentin 277
vitamin A metabolism 280–2
media effects 282
Cellular retinaldehyde binding protein (CRALBP) 280
human RPE culture 281
retinitis pigmentosa 299
vitamin A metabolism 280, 281
Choline acetyltransferase
retinal development 58, 59
Western Blot 281
Chondroitin sulphate glycosaminoglycan
cone matrix 229, 230
subretinal space 235
Ciliary body 48
Ciliary epithelium development 48–52
antibody RET-PE2 50, 51
folding mechanism 50, 52
lens induction 48, 50
stages 48
structure 48, 49
microscopy 49
transplantation experiments 48, 50
Ciliary neurotrophic factor 48
Circadian activity, *Limulus* efferents 334–6
ommatidia 336
Colour vision development and age 114
Cone
aging effects 108
aperture 111
blue, distribution 95
packing geometry 95, 96
dark-adapted, light response 37
degeneration 236
density 92
development 102
development in macaque 103
variability 93
deprivation effects 107
distribution 92
eccentricity effects 100
and density 105
foveal, development 102
shape and age 103
ganglion cell convergence 97, 98
generation 106
human, density 94
mammalian, numbers 92
moire, patterns 110
morphology 96, 97
peripheral retina 97
processes 96
optical quality 110
packing geometry 110, 111
receptor potential, electroretinogram 153–5
red/green 96
rod-free zone 107
spacing 108
resolution acuity 110
visual acuity 109
synaptic region development 104
topography and development 105–7
retinal growth 106
Cone matrix sheaths 215, 225–43
biochemical characterization 225, 231
bovine 226
chondroitin sulphate 229, 230
development 235
Western Blots 233, 234
constituents
known function 238
roles 238–42
developmental expression 233
glycoproteins 227, 228
immunocytochemistry 235
interphotoreceptor matrix 226
lectin localization 225, 227, 228

microscopy 226
monkey 226
proteoglycan localization 228–33
retinal attachment 239, 240
retinal degeneration 236–8
remnants 236, 237
sheet separation 231, 232
synthesis 233
xyloside exposure 240, 241
Cone mosaic
chromatic submosaic 95, 96
foveal 93
packing geometry 93, 95
peripheral array 110
Contrast sensitivity function 111
shape and age 113
Corticotropin-releasing factor (CRF)
amacrine cells 13
inner plexiform layer 14
structure 13
turtle retina 13–15
function 14, 15
Cryopreservation, RPE cell culture 268, 269

Dark adaptation 27
Dark rearing 107, 108
Dehydration, tissue effects 91
Development, photoreceptor mosaic 101, 102
Dihydroretinols, structure–activity studies 170
fish retina 11
turtle retina 9–12
detection 9
injection experiments 11
release, factors affecting 12
Dopamine neurons
aldehyde-induced fluorescence 57
retinal development 57
tonic inhibition 12

Efferent innervation
circadian activity in *Limulus* 334–6
Limulus eye 333–51
retinal structure 343
visual functions 338–43
octopamine 343–5
mediation and cAMP 346–50

Electroretinogram
background adaptation 129, 130
cat 129, 130
clinical 126
components 127–9
current initiation 127, 128
early receptor potential 125, 126
experimental 126, 127
field potentials 122
history 123, 124
intraretinal 129
Müller cells 128
M-wave 122
negative components 121–56
PIII
fast and slow 124, 125
proximal and distal 126
remnant negativity 124
pattern 122
recording system 127
rod, Granit's analysis 123
vitreal 129
Electroretinogram, dark-adapted 130–47
A-wave 132, 133, 144
amplitude and stimulus 134, 137
APB effects 135, 137
aspartate effects 133–5
intensity series and species 132, 133
kynurenic acid 136
off-response 136–8
origin, negative components 138–44
$BaCl_2$ effects 140, 141
current source density 138, 139
depth distribution 138, 139, 141
neuronal 142–4
potassium measurements 139, 140
potassium-Müller cell mechanisms 140–2
threshold circuit 144
potassium and stimulus intensity 135, 137
retinal depth 131
rod receptor potential contributions 144–7
B-wave trough 146
C-wave 146, 147
diffuse stimuli 146
light step response 145
scotopic PII 131
scotopic threshold response 130–4
GABA 143
glycine 143, 145

origins 142, 143
picrotoxin 143, 144
slow negative response and intensity 133, 136
species comparison 136, 137
vitreal 130
x-linked retinoschisis 135
Electroretinogram, light-adapted 147–55
barium effects 149–51
C-wave 151, 152
amplitude and intensity 152, 153
components 152
cone receptor potential 153–5
diffuse flash, primate 154
and aspartate 104
diffuse stimuli 147, 148
M-wave 147–9
APB effect 148, 150
aspartate effect 148, 150
PIII 149
picrotoxin effect 148, 149
tetrodotoxin effect 148, 149
PIII fast and slow 149
red and blue stimuli 150–2
rod receptor potential 151–3, 156
species comparison 153
sustained negative response 129, 147
Eye cups
culture medium 165
retinal regeneration 165

Feedback regulation, retinal cell formation 57
Filters, scotopically matched red and blue 150, 152
Fixation, interphotoreceptor matrix 210, 211
Fovea
development 102
spatial vision 112–14
photoreceptors 91
Foveal pit development 102

GABA
scotopic threshold response 143
tiger salamander 40
turtle retina 2–4
amacrine cells 3, 4
ganglion cells 4
horizontal cell response rise time 38, 39
5-HT 3
GABAergic system and retinal development 58
Ganglion cell
cone convergence 97, 98
death 101
on, rod pathways 142
synaptic connections 30
Ganglioside, JONES in retinal development 55, 56
Glial cells, retinal development role 59, 60
Müller 59
Glucagon
structure 16
turtle retina 16, 17
amacrine cells 16
light response 17
Glutamate
horizontal cell synapse 38, 41
turtle retina 1, 2
Glycine
horizontal cell response rise time 38, 39
salamander retina 40
scotopic threshold response 143, 145
turtle retina 4, 5
dopamine release 5
Glycoprotein, TOP in retinal development 55
cGMP in retinitis pigmentosa 297, 298

Hoffman modulation contrast microscope 29
Horizontal cells
light responses, dark-adapted 37
response rise time 38, 39
response and rod-cone coupling 40–2
retinal sensitivity 40
rod input–output relation 33
synapse, scheme 38, 41
6-Hydroxydopamine and retinal cell types 57
5-Hydroxytryptamine (5-HT, serotonin)
retinopetal system 9
turtle light effects 7
turtle retina 5–9
amacrine cells 7, 9
bipolar cells 6, 7
detection 6
5-HT neurons
aldehyde-induced fluorescence 57
retinal development 57

Ideal observer 111
Immunocytochemistry, retinal pigment epithelium cell transplantation 75, 77, 78
Inner plexiform layer
  corticotropin-releasing factor 14
  dendritic branching 10
    fish 11
  neuropeptide immunoreactivity 14–23
Interphotoreceptor layer 207–43 *see also* cone matrix sheaths
  apical–basal heterogeneity 216, 217
  biochemistry 217–21
  cell source 222, 224
    techniques 224
  chondroitinase incubation 233, 234
  constituents 218–21
    absent 220
    enzymes 219
    glycosaminoglycans 219, 221
    proteins 218–20
    proteoglycans 228–33
  developmental expression 221, 222
    lectin use 222, 223
  features 208, 209
  fixation effects 210, 211
  histochemistry 212
  lectin study 212–16
    HAA 215
    PHA 215, 216
    PNA 213
    WGA 213, 214
  organization 210, 212
  photoreceptor cell type heterogeneity 217
  retinal attachment 239, 240
  retinal detachment 224, 225
  sheet separation and urea 231–3
  soluble components 209
  structural analysis 209
  ultrasound studies 209, 210
  xyloside exposure 240, 241
Interphotoreceptor space 208
Interplexiform cells, GABA and glycine 40
Interstitial retinal binding protein 216–18
  retinal detachment 225
Isomerase system *see* visual cycle

Kainic acid, retinal cell types 57

LANT-6, turtle retina 20, 21
  ganglion cells 21
  inner plexiform layer 14
Leber's amaurosis 317
Limulus eye
  anatomy 335
  ommatidia 336
Limulus lateral eye
  A-fraction phosphorylation 347, 348
  calcium effects 350
  diurnal changes 339
  factors affecting 339, 340
  lateral inhibition 341
  mechanisms of changes 340
  mitochondrial distribution 341
  neurotransmitters 337, 338
  octopamine effects 342
  P-fraction phosphorylation 347, 348
  photosensitive membrane 335, 336
  retinular cell electrophysiology 340, 341
  rhabdom shedding 340
Lipid metabolism, retinitis pigmentosa 301

Macaca spp, gestation 101
M. nemestrina, rod numbers 101
Macular dystrophy, genetics 297
Membrane
  metaretinochrome 193, 194
  metarhodopsin 195, 196
    and rhodopsin 196, 197
  Todarodes preparation 192
Met-enkephalin (M-ENK)
  turtle retina 17
    inner plexiform layer 14
    light responses 180
Monkey eye processing 257, 257
Müller cells
  electroretinogram components 128
  potassium-induced current flow 128
    amphibia 142
    conductivity distribution 142
    mechanism 140–2
    model 155
    scotopic threshold response 142
  –rod interaction 60
Myeloid bodies 186

Neuropeptides *see also* individual compounds and dopamine release 12
Neuropeptide Y

actions 15
inner plexiform layer 14, 15
turtle retina 15, 16
function 15
Neurotensin
effects 18
turtle retina 18–20
actions 20
amacrine cells 19
vesicles 20
Neurotransmitters *see also* individual compounds
retinal growth factors 58, 59
turtle retina 1–23
Nomarski optics 92
Nyquist frequency 108
gratings 109

Octopamine
effects 345
light sensitivity 344
Limulus eye effects 343–5
photoreceptor physiology 344
retinal sensitivity factors 345
stimulated phosphorylation 346–8
synthesis and storage 337
Octopaminergic neurons in *Limulus* 333–51
cAMP effects 346–8, 350
efferent innervation 343, 344
eye responses 338
122KDa phosphoprotein 346–9
lateral eye effects 342
vertebrate relevance 350
Opsin
expression
fibroblast growth factor 63
molecular genetics 61–3
regulation 62, 63
gene coding 61, 62
immunocytochemistry and RPE transport 77, 78
labelling 61
metabolism 61
promoter regions, amino acids 62
mouse 64
transducin 63, 64
Opsin positive cells, retinal development 60, 61
Optic cup development 45–64 *see also* ciliary epithelium, retinal pigment epithelium
complexity 45
E13, electron microscopy 47
layer development 52
retinoic acid 46
Optic stalk development 46, 48
platelet derived growth factor 48
Optic vesicle
differentiation 46
scanning electron microscopy 46, 47

Parafoveal ring 106
Pargyline 6
Photoreceptor anatomy and visual performance 113
Photoreceptor cell layer transplantation
dissociated 82
technique 82
Photoreceptor cell rescue
factor 79
factors affecting 79, 80
transplantation 75, 77
Photoreceptor mosaic
cell turnover 101, 102
colour vision 114, 115
composition 99
cone 92–8 *see also* cone
spacing 108–10
density 93–5
eccentricity effects 100
functional significance 108–12
development 112–15
historical 90
human, appearance 99, 100
optics 111, 112
rods 98–100 *see also* rods
spatial vision 111, 12
monkey 114
Photoreceptor synapses 27–43
adaptation-induced modulation 33–8
functional implications 38, 40–3
input–output relations 34, 36
light responses 37
rod–cone coupling and light 33, 34, 42
second-order cells 34–7
waveforms 34–7
complexity 28
dark-adapted conditions 30–3
coupling 30

photoreceptor interaction 31, 32
rod current injection 31–3
rod input–output 33
signal transmission 32
voltage responses 31, 32
horizontal synapse 38, 41
infrared illumination 28, 29
living retina 29
on-centre module 30
study methods 28–30
Potassium
intraretinal and light 139, 140
Müller cells 128
field potentials 140
mechanism 140–2

Rat, dystrophic, RCS 73, 74
defects 73, 74
Receptors, dopamine D_1
horizontal cells 11
Regeneration, CNS 70
Rejection, retinal transplantation 81
Retina
periphery, photoreceptors 91
whole mount preparations 91
Retina development 55–60 *see also*
rod cell formation 55–8
feedback regulation 57
cell location 57, 58
central 102–4
choline acetyltransferase levels 58, 59
GABAergic effects 58
β-galactosidase marker 56
glial cell role 59, 60
growth factors 58, 59
migrations 106
neuron precess growth 59
peripheral 104, 105
precursors 55, 56
11-*cis*-Retinal
binding protein 174
biosynthesis site 166
chromophore metabolism 61
instability 174
regeneration 162
frog eye cups 165
in vitro 164–7
squid irradiation 199, 200
all-*trans*-Retinal
isomerase substrate 167–70
pigment epithelium processing 168, 170
release 162
retinyl ester formation 168, 169
squid retinal-binding protein 188, 189
Retinal adhesion, interphotoreceptor
matrix 239, 240
Retinal-binding protein, squid visual
cell 179–204
Retinal degeneration 262
cone matrix sheath molecules 236–8
Retinal detachment, interphotoreceptor
matrix 224, 225
Retinal development, thymidine birthdating 56
Retinal dystrophies and transplantation 80
Retinal function regulation, octopaminergic
neurons 333–51
Retinal pigment epithelium (RPE)
cell culture methods 251–85 *see also* cell
culture
cell isolation 74
cell transplantation 74
debris 76
microscopy *in oculo* 74, 76
development 52–5
cell culture and types 53, 54
cell monoclonal antibodies 52, 53
differentiation 52
human
dispase treatment 255
dissection 254, 255
fetal 257
preservation 254
procurement 253
transport 254
immunostaining 76–8
membranes, isomerase substrate 167–70
monkey, processing 256, 257
transplantation applications 80, 81
dystrophies 80
senile macular degeneration 81
trophic factors 84
Retinitis pigmentosa 293–318
aetiology 294
animal models 307–17 *see also* animal
models
phototransduction enzyme 308

features 293
genetics 294–7
autosomal dominant 295
autosomal recessive 294
complete penetrance 295, 296
defect 299
diffuse 295
X-linked 296, 297
cGMP 297, 298
immune system 307
light damage 302–5
age 303–5
lipofuscin 303
taurine role 304, 306, 307
vitamin C role 304
vitamin E role 303
onset 304
opsin synthesis 301, 302
outer segment renewal 302
outer segment structure 309–17
photoreceptor function 297–307
photoreceptor lipids 300, 301
phototransduction 297
retinal pigment epithelium cell culture 318
11-*cis*-retinol depletion 300
visual cycle 299, 300
vitamin A transport 299, 300
Retinoids
isomerization 164
system 170–3 *see also* visual cycle
label experiments 164
visual system 162, 163
Retinol transesterification 174
11-*cis*-Retinol, all-*trans*-retinyl ester processing 176
all-*trans*-Retinol
squid irradiation 199, 200
squid retinal-binding protein 188, 189
Retinol ester synthesis 173
Retinoschisis, X-linked, electroretinogram intensity synthesis 134
11-*cis*-Retinyl palmitate
eye cup *in vitro* production 166
all-*trans*-retinyl palmitate
pigment epithelium processing 168, 170
11-*cis*-retinol processing 176
Rhodopsin 161 *see also* squid
light effects 161
regeneration in visual cycle 165
Rod
aging effects 108
cone coupling and light 33, 34
photoreceptor synapse 42
current injection responses 34
bipolar cells 31–3
horizontal cells 31–3
degeneration 236
density, human 93, 94
development 60–3
differentiation, markers 60, 61
opsin 60, 61
regulatory step 63
distribution 98, 99
eccentricity effects 100
free zone, diameter and development 102, 106
gene co-regulation 63
increment threshold and light 33, 35
input–output relations 34, 36
bipolar cell 36
horizontal cell 36
light responses, dark-adapted 37
low-light vision 112
morphology 99
numbers, human 98
on-β ganglion cell pathway 142
peripheral development 105
photoresponse and electroretinogram 144–7
receptor potential and electroretinogram 151–3, 156
ring 99, 105
synaptic region development 104
topography 98, 99
birth 105

Scotopic threshold response 130–4, 142–5 *see also* electroretinogram, dark potassium-induced current flow 155
Senile macular degeneration, retinal pigment epithelium transplantation 81
Serotonin *see* 5-HT
Somatostatin, turtle retina 21
inner plexiform layer 14
Spatial vision
fovea development 112–14
monkey, factors 114

Squid metaretinochrome 184, 185
Squid opsin 185
Squid retina
black pigment 181, 182
photopigments 180–5 *see also* individual pigments
metaretinochrome 184
Squid retinal-binding protein (RALBP) 185–90
absorption spectrum 181, 187
amino acid composition 204
basement membrane 186
blue light response 187
discovery 185
exchange mechanisms 198
extraction 186
ligands bound 188, 189
preferential 190
localization 90, 203
visual cell micrography 190, 191
membrane preparations 192
metaretinochrome membrane 193, 194
metarhodopsin membrane 195–7
photoreaction 187
purification 186, 187
retinol isomer coupling 188
retinal-metapigment exchange 190, 192, 203
time-course 197, 198
retinal-metaretinochrome exchange 192–4
supernatant 192, 193
retinal-metarhodopsin exchange 194
supernatant 194, 195
retinal–retinol shuttle 186
retinochrome formation 194
retinoid binding 187
retinoid ligand replacement 188–90
retinol ligands 202
all-*trans*-retinol uptake 195
rhodopsin formation 196, 197
visual cell movement 199
Squid retinochrome 182, 183
absorption spectrum 181
decomposition 188
hydroxylamine 183
light and dark reactions 183
localization 184, 185, 198
fluorescent micrographs 185
orange irradiation 183
rhodopsin system 198–202
Squid rhodopsin
absorption spectrum 181
fluorescence microscopy 184, 185
localization 184, 185
orange irradiation 182
stereoisomerism 182
Squid rhodopsin-retinochrome system 198–202
dark adaptation 199
eyecups preparation 199–201
irradiation, retinal proteins 199, 200
RALBP movement 199
scheme 199
Squid visual cell
chromophore exchange system 179–204
scheme 181
Substance P, turtle retina 21, 22
inner plexiform layer 14
Synaptic vesicle membrane protein (SVP 38) 60
Synaptophysin 60

Taurine
carrier 306
deficiency 307
origin 305
retinal entry 306
retinitis pigmentosa 306, 307
role 304, 305
Todarodes pacificus 180 *see also* squid
Transducin, amino acid sequences 63, 64
Transplantation, CNS 70, 71
early studies 70
vascular bed 70
Transplantation *in oculo* 69–85
cell 82
layer 82
early studies 71
functional characteristics 83
recognition and host tissue 83
regions 71
retinal pigment epithelium cells 73
ATPase 75, 78
Bruch's membrane 81
cell rescue 75, 77
human, applications 80, 81
immunocytochemistry 75, 77, 78
immunostain 77, 78
microscopy 74–6
opsin 75, 78

RCS dystrophic rats 73–7
reattachment 74
rejection 81
rescue factor 79, 80
sham injection 79
sympathetic ophthalmia 81
techniques 74
transitory survival 80
whole retina 71–3
axonal connection 73
critical cell populations 73
grafting procedure 72
microscopy 72
rat types 72
success 73
Turtle, retinal neurotransmitter 1–23

Usher's syndrome 301
Uvomorulin 273

Vimentin, cell culture 277
Visual acuity, neonatal 113, 114
Visual cycle 161–76 *see also* individual components
classical 162
dynamic 163
enzymatic processes 161
equilibrium 163
isomerase specificity 169
isomerase system 170–3
coupled reaction 175
detergent effects 170, 173
isomerization drive 174–6
membrane sonication 171
phospholipase effects 170
polyene chain 171
positional selectivity 174
purification 173, 174
retinol concentration 172
supernatant 173
isomerization substrate 163, 164
all-*trans*-retinol
retinitis pigmentosa 299, 300
Visual transduction cascade 162
Vitamin A 162
metabolism in retinal pigment epithelium 280–2

Wheat germ agglutinin, interphotoreceptor matrix 213
glycoconjugates 214

Zebra stripes 109
Zwittergent-3,14 173